Science Education International
32(3), 185-190
https://doi.org/10.33828/sei.v32.i3.1

ORIGINAL ARTICLE

Chemical Security in Somalia: An Assessment Survey about the Chemical Safety and Security Status in Somalia

Abdolahi Mohamed Adawe[1,2]*

[1]Department of Chemistry, Graduate School of Science, Eskişehir Technical University, Eskişehir, Turkey, [2]Somali Chemical Society, Mogadishu, Somalia

***Corresponding Author:** cadaawe100@gmail.com

ABSTRACT

Chemicals used in academic teaching laboratories, research institutions, and industrial facilities are mostly dual-use chemicals. They provide many desired benefits but at the same time may cause adverse effects to human health and environments. In the case of Somalia, there are gaps in terms of chemical security (CS) awareness and implementations, and this has resulted in terrorist attack involving dual-use chemicals. To fill this gap, over the past 5 years, the Somali Chemical Society has conducted CS training for CS practitioners from both academia and industry. These training sessions have uncovered a lack of basic knowledge among chemical practitioners about chemical safety and security. The aim of this study was to assess the safety and security systems in Somalia. The research method was an investigative survey to explore information related to the chemical safety and security systems in Somalia. The study was conducted with 20 universities in the country to evaluate their understanding of chemical safety and security. The questionnaire was answered by chemistry lecturers, university students, laboratory managers, and government lab personnel. One hundred and ten participants were selected through cluster sampling. Data were collected through a closed ended questionnaire. The reliability of the study resulted Cronbach's Alpha coefficient of 0.933. A noteworthy finding indicated that the chemical safety and security status in Somalia was inadequate, and coordinated efforts by all stakeholders including Government, university leaders, and scientists from different disciplines are urgently needed for effective reforming of chemical safety and security in Somalia.

KEY WORDS: Chemical safety; Chemical security; Somalia

INTRODUCTION

The lab is described as a place where scientists can work safely and securely. However, in the absence of an effective safety and security system, it can also become a dangerous place to human health and the environment (Karapantsios et al., 2008; Sedghpour et al., 2013). The safety management system plays an important role in minimizing incidents that happen in the lab, but it depends on how technicians, students, and other workers who run the lab are trained and equipped with knowledge about safety and security courses. Mistakes in labs do not happen; instead they are caused and are preventable in many instances (Babinčáková et al., 2020; Renfrew, 1981). Most of the risks associates in labs can be avoided when well-planned and research tasks are carried out smoothly without interference. (Al-Ibadi, 2016; Green and Turk, 1978; Hui et al., 2009; Zhao et al., 2007). However, if there is no safety program, the lab may cause harm to humans.

Often safety programs are given a higher priority in developed countries, but often neglected in developing countries (Kandel et al., 2017) to include Somalia. As Somalia went through a civil war for almost three decades causing widespread destruction including the education sector and other government institutions this could be the reason of why Somalia has neglected implementing chemical safety and security best practices. Despite this, however, there are other factors that contribute to the challenges in implementing chemical safety and security best practices among stakeholders in the chemical sectors: (1) lack of chemical safety and security awareness or safety culture among leaders, and personnel in the industry and academia; (2) financial limitations; and (3) management barriers, such as lack of support and commitment from industry and academic leaders discourage the cultivation of a safety culture among the components. This creates difficulties obtaining financial support from the chain of authority to support safety and security measures in laboratories. As a result, Somalia has been considered a hot bed of terrorism in the region which makes security a main concern even in the academia. Although universities in Somalia generally use chemicals in typically small quantities, they are still considered a vulnerable target for chemical misuse, theft, and diversion. Furthermore, there have been constant acts of terrorism involving dual-use chemicals, such as the 2011, 2017, and 2019 blast attacks on Mogadishu, the capital city of Somalia.

The term "dual-use chemical" refers to a substance that can be used for both beneficial and harmful purposes and these substances are often traded in large quantities within and across

Science Education International
32(3), 185-190
https://doi.org/10.33828/sei.v32.i3.1

borders with little restriction. A number of dual-use chemicals are regulated as chemical weapons (CWs) because they have a history of being used as such. Chlorine gas, trinitrotoluene, and ethyl bromoacetate are examples of chemicals used during WWI as weapons. Dual-use chemicals also include hydrochloric acid, hydrogen peroxide, triacetone triperoxide, and nitrate compounds such as ammonium nitrate, because of their beneficial applications in teaching and agricultural activities (Walters et al., 2015). For instance, on October 4, 2011 a terrorist attack took place at the Hargaha and Saamaha building in Mogadishu, Somalia, resulted in 100 deaths, mostly students. More than 40 were wounded. Regarding the materials ammonia nitrate fertilizer and diesel fuel–commonly referred to as ANFO explosive were believed to have been used in that explosion. On October 14, 2017, a massive blast took place at the Zoobe Junction, Mogadishu killing at least 600 and injuring nearly 400 others. The primarily investigation determined that the explosion was caused by dual-use chemical with quantities estimated over 1200 kg of potassium nitrate and TNT. On December 28, 2019, the Ex-control Afgoi, a busy area with security check points in Mogadishu, was also another target of an attack planned by terrorist group. A total of 100 people, including a dozen students from Banadir University died in that attack and more than another 50 were injured. These three incidents of terrorism were the deadliest bombings in Somalia and caused widespread community damage.

Physical security can be defined as protecting people, property, and facilities through the use of security forces, security system, and security measures, defining security system requirements and assessing internal and external threats to assets as well (Fennelly and Perry, 2016). In the case of Somalia, the physical security used in academic teaching laboratories, research institutions, and industrial facilities include buildings with lockable doors and windows, boundary, and internal walls. In terms of operational security, security guards are stationed at entry and exit points to conduct inspections of personnel and cars entering and leaving the university premises and other institutions.

It is, therefore, important to give more effort to advance chemical safety and security awareness programs and best practices for chemical facilities in academia and industry to mitigate threats to chemical security (CS) in Somalia and make sure the safety of lab personnel which comply with both the revised Labor Code and Civil Service Law for Somalia, Law No. 11, 2006, article 10, which regulates the safety and health of the work place (MoLSA, 2006). Nevertheless, many chemical safety best practices overlap with CS best practices, but there are important differences. Chemical safety means preventing and protecting against accidents in chemical laboratories while the CS refers to measures to prevent and protect against the intentional misuse of chemicals, people, or equipment for non-peaceful purposes. In a wider context, it also includes policies to prevent attempts to acquire toxic chemicals or CWs precursors (Al-Khalaf, 2016; Engida, 2011; Kandel et al., 2017; Karapantsios et al., 2008; Khakzad et al., 2018; National Academies of Sciences and Medicine, 2016; NRC, 2010; 2011).

Steps Taken to Promote CS Awareness and Best Practices in Somalia

Since 2016, several initiatives have been implemented in Somalia to raise awareness of CS for employees in academic, industrial, and government facilities. These initiatives targeted laboratories, research, teaching, procurement, logistics, emergency response, and administrative personnel. Other target populations for this training included sellers of pharmaceuticals, agrochemicals, and end users of assorted chemicals in the informal and unregulated chemical sectors. Some of the approaches used to create CS awareness and provide best practices are highlighted below.

CS Training

The Somali Chemical Society (SCS) has worked with several partners, largely supported by funding from the US Department of State's CS Program (CSP) and implemented by their cooperated bodies such as Sandia National Laboratories (SNL), American Chemical Society (ACS), CRDF Global and Pacific Northwest National Labs (PNNL) to reduce the threat of misuse of chemicals. The trainings have been accomplished through workshops and seminars. Some of the topics covered include procurement Chemical Supply Chain, fundamentals of Chemical Safety and Security, Chemicals of concern and Dual-Use Chemicals, Standard Operating Procedures, Chemical Inventory Management System, physical security protection, personnel reliability Chemical Storage best practices and Assessment tools and best practice. Participants in these trainings have included personnel from universities, government laboratories, industrial facilities, the agrochemical sector, the pharmaceutical sector, with the total of 350 participants as of February 2021. As a result of this, there are steady improvement in terms of chemical safety and security awareness in Somalia.

E-learning Platform

Due to the global COVID-19 pandemic, SCS has conducted and organized in both in-person training and online chemical safety and security e-learning programs to spread CS awareness to remote areas and those with limited time due to work commitments. The purpose of the online training was to enhance stakeholders' understanding of threats to dual-use chemicals assets and strengthen their initiatives to ensure adoption of security measures. To make the training programs more effective, the trainings and educational materials have been translated to the local Somali language which has enabled dissemination of CS knowledge to a wider audience in Somalia. The participant feedback showed that the e-learning platform was convenient tool for CS training.

To this study's author's knowledge, there are no previous studies that have been reported on safety and security situation in Somalia, this study appears to be the first study to assess the correlation between chemical safety, security variables,

Science Education International
32(3), 185-190
https://doi.org/10.33828/sei.v32.i3.1

awareness programs, and their improvement. Therefore, the purpose of this study was to evaluate the current status of chemical safety and security in Somalia. The author conducted the survey among chemistry lecturer, university student, laboratory manager, and government lab personnel through a closed-ended questionnaire wishing to make contributions in an effective chemical safety and security best practices in chemistry undergraduate curricula in the educational system of Somalia.

METHODOLOGY

Research Questions

Research questions were developed in constructive way and used Likert scale 1–5. The items of the survey questions were written in a straightforward manner using language that was easy, accurate, and understandable to respondents. One focus was stated to be "The impact of chemical safety and security awareness in reducing risk associated from chemical incidents and accidents in Somalia." The survey was carried out between December 2019 and September 2020. The results of the respondents were analyzed and evaluated statistically using IBM SPSS.20 and IBM AMOS 23 Software.

Procedure

This study was done through a survey questionnaire. This technique was used to measure the ideas of group of people namely: Chemistry lecturer, university student, laboratory manager, and government lab personnel. The reasons we selected this model were to achieve sufficiently high level of reliability and get information with high precision. As noted, the study targeted four groups of respondents; the majority of the four groups were composed of undergraduate students who were almost finished with their study. The study also included graduated chemists with a Master of Science and a small group of PhDs in chemistry who are working as a chemist in both private and state universities in Somalia. Voluntary participants were selected through cluster sampling from different universities in Somalia, participants from private companies and government institutions and Banadir regional administration were also included in the survey. The questionnaire was answered by one hundred and ten participants. The designed questionnaire was used to collect information from participants. The questionnaire evaluated the degree of agreement and disagreement of all the respondents with matters concerning chemical safety and security from their point of view. Data for this study are taken through a closed-ended questionnaire.

RESULTS AND DISCUSSION

Results

Factor analysis is a technique used to simplify a large set of data into a smaller manageable set of data and validate the model used. As it is highlighted in Table 1, the KMO index was 0.718 which is higher than the 0.6 which indicates that the data collected are well suited for conducting factor analysis (Field, 2013). Beside this the null hypothesis was rejected in Bartlett's test of Sphericity of which it was 512.912 with a degree of freedom of 105. This means that the items in the questionnaire for validating the status of chemical safety and security in chemistry laboratories have enough correlation for factor extractions.

Data cleanup were conducted before running factor analysis and eight respondents were not answered the questions properly as evidenced their same responses; therefore, they were removed due to this, all the variables were internally consistent and reliable. Fourteen variables were considered in the study because of their significance. For CS situation seven factors were statistically significant, namely: CS system, Government role in developing policy, Emergency Responses for CS incident, Detection system, Security cameras, Security Professionals, and Risk Communication tools. For chemical safety seven factors were statistically significant, namely: Safety system in the chemistry labs, safety per-orientation, certified first aid kits, safety tools, safety manual, spill control materials, and government role in developing safety guidelines.

Concerning the CS item, seven items of CS were examined. Among the CS items, "Government role in developing policy for chemical inventory control is functioning" and "Security cameras are available in chemical storage" received relatively the highest rating followed by "Effective CS system is available in chemistry labs." The most frequent CS variables towards the targeted Chemistry lecturer, laboratory manager, Government lab personnel, and university student was Chemistry lecturer group who has given all the items to the highest frequent rating ($M = 2.603 \pm 1.268$) followed by university student who gave high important to all items for CS performance where ($M = 2.749 \pm 1.344$) and followed by government lab personnel and laboratory managers. This points out that the CS system in the Somalia is at an inadequate level. Therefore, improvements regarding the weakness areas of CS in the Somali higher learning institutions, industries, and commercial laboratories are necessary to be addressed.

Regarding chemical safety item, seven items of chemical safety were examined. The chemistry lecturer group gave all the items the highest frequent rating ($M = 2.225 \pm 1.181$) followed by university student ($M = 2.733 \pm 1.336$) then government lab personnel and laboratory manager. This indicates that there is a chemical safety system in the country though it is not as it is expected. Therefore, advancements regarding chemical safety system to better safety system in the Somalia are required.

Table 1: KMO and Bartlett's test for chemical safety and security performance

Level of significance	Degree of freedom	Bartlett's test of sphericity-approx. Chi-square	KMO size
0.000	105	512.912	0.718

Science Education International
32(3), 185-190
https://doi.org/10.33828/sei.v32.i3.1

Impact of Awareness Programs on Chemical Safety and Security System

Within the aim of this study, awareness was a common factor that could have a positive impact of improving chemical safety and security system in academic teaching laboratories, research institutions, industrial facilities, and commercial laboratories. In this study, the item which do not directly relate to the chemical safety and security respectively was excluded from the study, with the IBM Amos software 23 version, it has been found that how the awareness impacted the performance of chemical safety and security system respectively and also covariance between independent variables, as it can be seen the result shown in Figures 1 and 2.

Impact of awareness on improving CS system: According to the information obtained from IBM Amos software 23 version as highlighted in Figure 1, seven factors were extracted which were statistically significant as well as the impact of awareness to practice of seven factors were studied. The impact of awareness to emergency response was 0.98, detection system 0.591, security cameras 0.972, having security professional 0.89, having risk communication tools 0.78, increasing the awareness results the good practice of effective security system which was about 0.963 which means when awareness goes up by 0.963 approximately 1 standard deviation, practice goes up by 1 standard deviation and the last which leads for developing policy for inventory control is about 0.75. The estimation was based on any indicator that its estimation was more than 0.5 made in one group which means all security items total correlations were greater than 0.5. Both these results indicated that the sustaining awareness would have a positive impact of improving the security system in the academic teaching, research institutions, industries, and commercial laboratories.

Impact of Awareness on Improving Chemical Safety System

For the chemical safety system in chemistry labs, the information attained from IBM Amos software 23 version as highlighted in Figure 2, seven factors were extracted which were statistically significant as well as the impact of awareness to practice of those seven factors were also considered where the impact of awareness to orientation on safety was 1.000. First Aid kits were 0.933, Safety tools 0.456 which means it has less impact on safety tools, Safety manual was 0.972, Spill Control Materials 0.840, increasing the awareness results the good practice of effective safety system which was about 0.994 which means when awareness goes up by 0.994 approximately 1 standard deviation, practice goes up by 1 standard deviation and the last which leads for developing safety guidelines which is about 0.729. The estimation was based on any indicator that its estimation is more than 0.5 made in one group which means all security items total correlations were greater than 0.5. Both these results indicated that the sustaining awareness would impact positively on improving the safety system in the chemistry labs.

DISCUSSION

There are four factors that were used to collect the demographic information related to this study; identity was the first demographic variable in which the respondents were asked to classify themselves as either male or female. 37 respondents, or 34% out of the 110 respondents were females compared to 73 males, or 66%, this indicates a male control of the study,

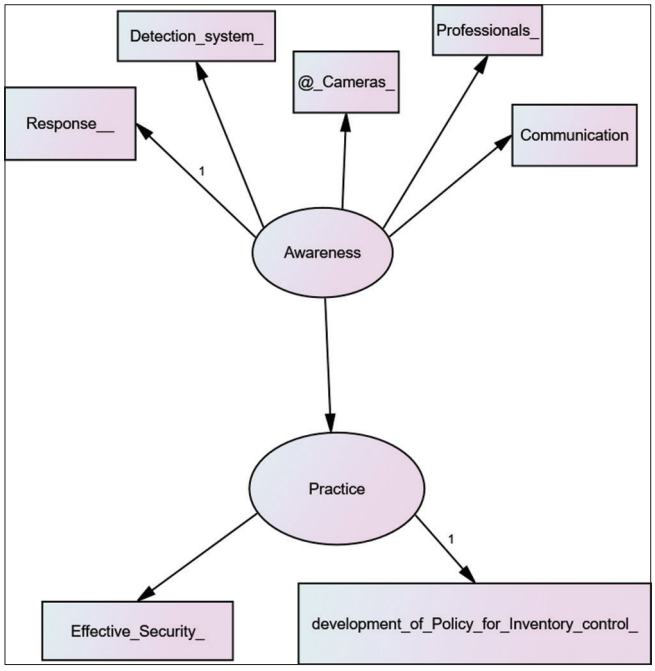

Figure 1: Diagram of awareness impact on improving chemical security system in chemistry labs. Chi-square = 83.831, Degrees of freedom = 13, and Probability level = 0.000

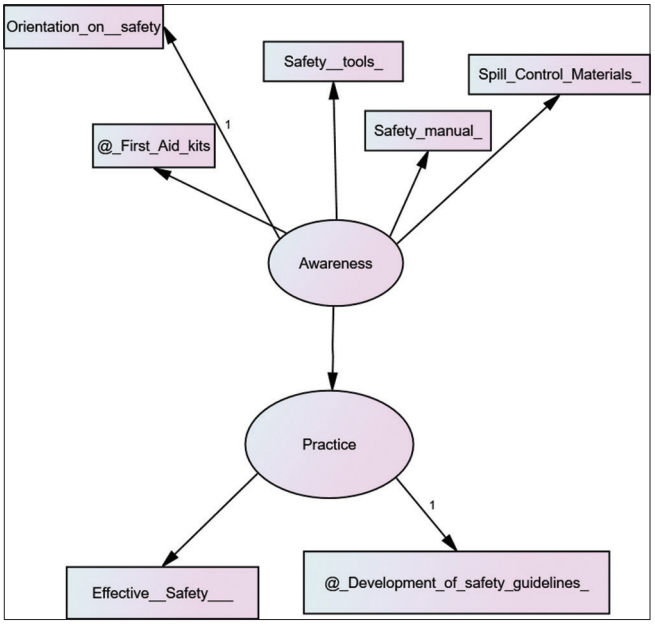

Figure 2: Diagram of awareness impact on improving chemical safety system in chemistry labs. Chi-square = 84.049, Degrees of freedom = 13, and Probability level = 0.000

Science Education International
32(3), 185-190
https://doi.org/10.33828/sei.v32.i3.1

but it is quite reasonable since the survey was targeting the chemistry professional in Somalia, the cultural issues make the difference in Somalia and allows males to outnumber females in the school, although, these days the numbers seem to be reversed if you see high school in the Somalia females are outnumbering males. The second demographic variables questioned the respondents their age. Out of 110 respondent 48 (44%) were between 20 and 30 year of age. 58 (53%) were between the age of 31 and 40 years old, but 4 (3%) were also between the age of 41 and 51 years old. As the data indicate huge number of the participants fall in the age of 30 and 40 age ranges. This mean more than 50% of this survey were chemistry lecturers at university level. This is quite understandable.

The third demographic variables inquired the respondent to describe their professional title, 54 respondent or (49%) were professional chemists, 37 respondent or (34%) identified themselves as a university student, ten respondent or (9%) identified as government lab personnel**,** the last group were nine respondent or (8%) identified as laboratory managers. More than 60% of the interviewed participants were professional and this is to make our analysis simple, we recorded this variable and put it as professional title therefore we have chemistry lecturer, lab manager, government lab personnel**,** and university student. The study also identified the educational background of the respondents, 56 out of 110 (51%) had a bachelor degree; 50, or (46%) a master degree, 4 respondents, or (3%) a PhD degree, as the study indicates the number of PhD holder in the field of chemistry is very small, as this might be the people have not interested so much in the field of applied science and this could be the reason of having less background understand on topics in relation to chemical safety and security in Somalia and definitely it is a worrying issue that is on the rise in Somalia.

CS System in Somalia

Regarding the CS situation in chemistry laboratories, seven items were examined. Among the CS items, the items "government role in developing policy for chemical inventory control is functioning" and "security cameras are available in chemical storage" both received the highest rating where 32% of respondents disagreed the statement which means the government role is quite absent and there is no security cameras available in the chemical storages, followed by the statement "Effective Chemical Security system is available in chemistry labs" where 29% of the respondents expressed their answer as "disagree" which is also indicates the limitations of security in Somalia.

Chemical Safety System in Somalia

Concerning the chemical safety items in chemistry laboratories, seven items were asked participants to express their idea. Among the CS items, the items "There is a shortage of certified first aid kits in chemistry Laboratory" received the highest rating of 41% where respondents have pointed out their neutral about this statements which means there are first aid kits in the labs though it is not enough as it is expected, followed by two item who also got the highest rating of 31% "Students start their lab without per-orientation about their safety" and "Safety manual is not available in the lab" both items respondents expressed their ideas as "strongly disagree statement," which gives the indication of there is a safety manual in the labs but requires to be improved and also the student receive pre-orientation about safety before they start their experiments in the labs. The participants were asked to express their ideas on the chemical safety situation, and elements of necessity. All the respondents have agreed on the necessity of reforming the education system in terms of higher learning institutions and industries. Moreover, they were also considered the current situation where a country like Somalia which is a recovering nation requires a time to upgrade the existing regulations and standards to improve the safety system in the country.

CONCLUSION AND RECOMMENDATIONS

The laboratory is where the chemicals are stored and used, and in case of misuse it can cause harm to the environment and people, therefore there should be a system and programs to mitigate this from happening. Safety and security program require consideration and serious commitment from all stakeholders including Government, university leaders, and scientists from different disciplines to ensure the safety and security system in this country. In this study, we presented our results based on a closed-ended questionnaire survey of safety and security status in the Somalia especially in the chemistry laboratories. The result we obtained from the study showed that the safety and security system in Somalia is inadequate. We conclude that this means that there has not been the appropriate attention paid to chemistry labs. Contrary to this, the paper also showed increasing the safety and security awareness programs through workshops, seminars, and trainings have made a positive impact of minimizing incidents and accident that generally occur in the labs by improving the skills of lab personnel, but much more work needs to be done.

Despite this, the governments should prepare a system to monitor the safety and security of academic teaching, research institutions, industries, and commercial laboratories, and continue updating the protocols and guidelines when educational reforming happen, the system should be applied not only the laboratories but also to monitor all supply chain of the chemical sector from procurement and transportation to the end users. Dual-use chemicals rules and regulations should be renovated by the Government and implemented by stockholders to ensure that the chemicals and materials they are supplying is in compliance with Government regulations and international standards. Furthermore, the authority should inspect unregulated and informal chemical market and to check all characteristics recorded to verify compliance with the standards and regulations to ensure the safety of the community. Considering the result of the survey, the study suggests the universities should increase the awareness of chemical safety and security programs and develop their own protocols for lab safety in general chemical safety and security

Science Education International
32(3), 185-190
https://doi.org/10.33828/sei.v32.i3.1

should be introduced into university curricula as a core subject and this will be a wonderful ambition and safety professionals should advocate for this as sub-discipline to have a place in the chemistry curriculum.

Limitations

This study has some limitations. It represents informative picture of "chemical safety and security situation in Somalia" it only clarifies some aspect of the chemical safety and security in the laboratories that are required to be discussed and how the current status is. In further studies will be enlightening to analyze in detail, finally it should be stated that this study was carried out to give preliminary information of current safety and security system in Somalia.

ACKNOWLEDGMENT

The author would like to thank the CS Engagement Program (CSP) of the US Department of State and their partners such as SNL, ACS, CRDF Global and PNNL for CS training and also would like to thank the Organization for the Prohibition of CWs (OPCW) for the opportunity to attend the OPCW Associate Program training, finally the author would like to acknowledge the outstanding contribution of the participants during the survey.

REFERENCES

Al-Ibadi, M.A.M. (2016). The chemical safety & security in the university of Kufa: Progress & challenges. *Iraqi National Journal of Chemistry*, 16(2), 96-105.

Al-Khalaf, A.K.H. (2016). Green chemistry & sustainability of chemical safety & security. *Iraqi National Journal of Chemistry*, 16(2), 71-81.

Babinčáková, M.R., Ristvej, J., & Ganajová, M. (2020). Security of chemical laboratories in schools & universities in Slovakia. *Journal of Chemical Education*, 97(7), 1756-1763.

Engida, T. (2011). Chemical safety in laboratories of African universities. *African Journal of Chemical Education*, 1(2), 35-49.

Fennelly, L.J., & Perry, M. (2016). *Physical Security: 150 things you should know*. Oxford, United Kingdom: Butterworth-Heinemann.

Field, A. (2013). *Discovering Statistics Using IBM SPSS Statistics*. Thous& Oaks, California: Sage.

Green, M.E., & Turk, A. (1978). *Safety in Working with Chemicals*. Basingstoke, United Kingdom: Macmillan College.

Hui, R., Hui, X.X., & Yi, L.W. (2009). Reflections on the safety management of laboratories in American universities. *Experimental Technology & Management*, 10(8), 4-7.

K&el, K.P., Neupane, B.B., & Giri, B. (2017). Status of chemistry lab safety in Nepal. *PLoS One*, 12(6), e0179104.

Karapantsios, T., Boutskou, E., Touliopoulou, E., & Mavros, P. (2008). Evaluation of chemical laboratory safety based on student comprehension of chemicals labelling. *Education for Chemical Engineers*, 3(1), 66-73.

Khakzad, N., Martinez, I.S., Kwon, H.M., Stewart, C., Perera, R., & Reniers, G. (2018). Security risk assessment & management in chemical plants: Challenges & new trends. *Process Safety Progress*, 37(2), 211-220.

MoLSA. (2006). *Revised Labour Code & Civil Service Law, 1972 for Somalia, Law No. 11*. Federal Government of Somalia, Federal Minister for Labour & Social Affairs, MoLSA.

National Academies of Sciences & Medicine. (2016). *Chemical Laboratory Safety & Security: A Guide to Developing St&ard Operating Procedures*. Washington, DC: National Academies Press.

NRC. (2010). *Promoting Chemical Laboratory Safety & Security in Developing Countries*. Washington, DC: National Academies Press.

NRC. (2011). *Prudent Practices in the Laboratory: H&ling & Management of Chemical Hazards, Updated Version*. Washington, DC: National Academies Press.

Renfrew, M. (1981). *Safety in the Chemical Laboratory*. Vol. 4. Washington, DC: American Chemical Society.

Sedghpour, B.S., Sabbaghan, M., & Sataei, F.M. (2013). A survey on the pre service chemistry teachers' lab safety education. *Procedia Social & Behavioral Sciences*, 90, 57-62.

Walters, D.B., Ho, P., & Hardesty, J. (2015). Safety, security & dual-use chemicals. *Journal of Chemical Health & Safety*, 22(5), 3-16.

Zhao, Q.S., Wen, X.H., & Li, M. (2007). Safety education being the key to keep the laboratories safe in universities. *Experimental Technology & Management*, 9, 8-11.